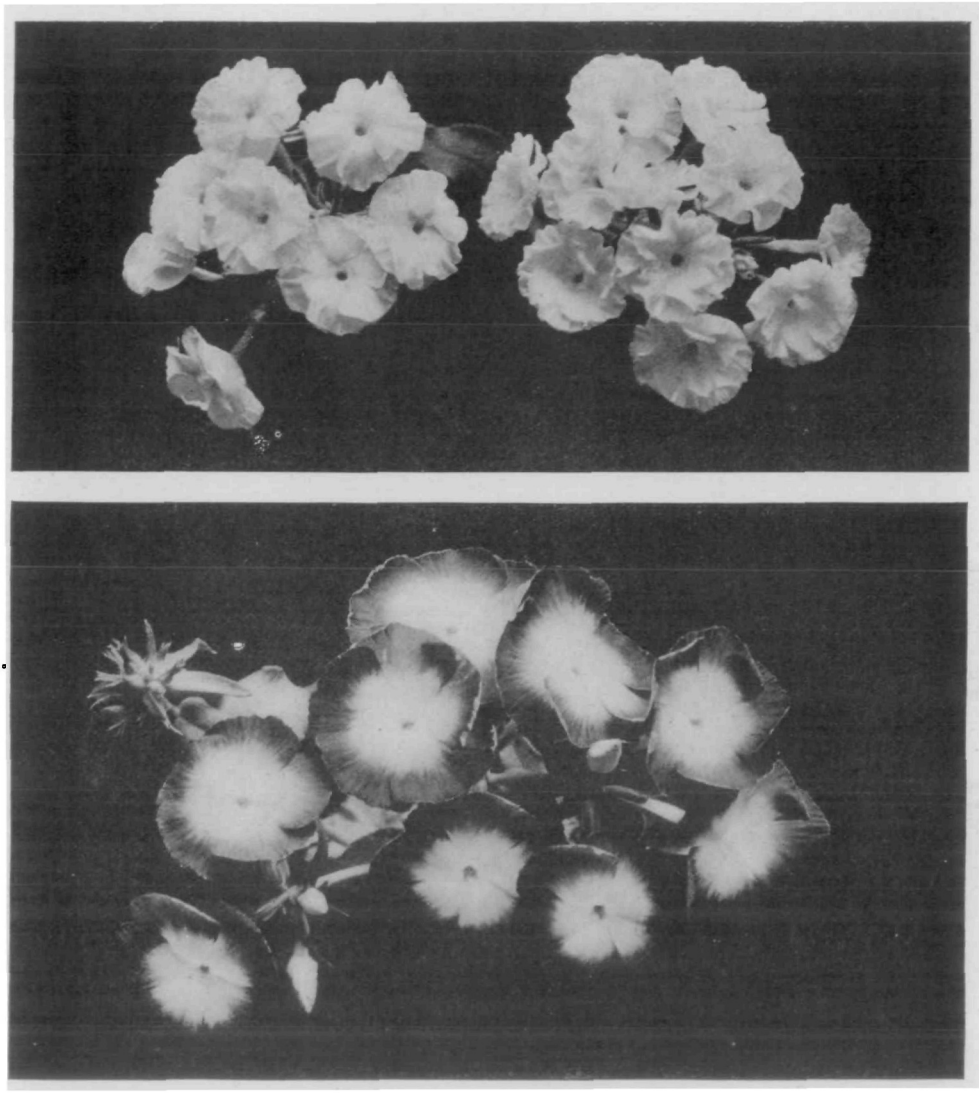

ASTYLIS AND ORBICULARIS PHLOX

FRONTISPIECE. As an illustration of how genetics enables us to analyze the hereditary make-up of living things this study of inheritance in phlox is instructive. The small, white-flowered, *astylis* form was found in a supposedly pure strain of small-eyed phlox (Figure 1), and also appeared on inbreeding the large-eyed *orbicularis* variety. Crosses were then made between *astylis* and small-eye and the plants of this first hybrid generation were all of the *orbicularis* type. That is, small-eyed and *astylis* are genetically pure strains, which normally would be expected to breed true (if *astylis* were not self-sterile), while *orbicularis* is of hybrid origin, containing the genes *astylis* and small-eye in the heterozygous condition. The hereditary determiner of the small-eyed character is only partially dominant over *astylis,* and the *astylis* "blood" has the effect of inhibiting the development of anthocyan color except in the periphery of the petals.

ASTYLIS PHLOX

The Relation of This Variation of Phlox Drummondii to the Large-Eyed Flower[1]

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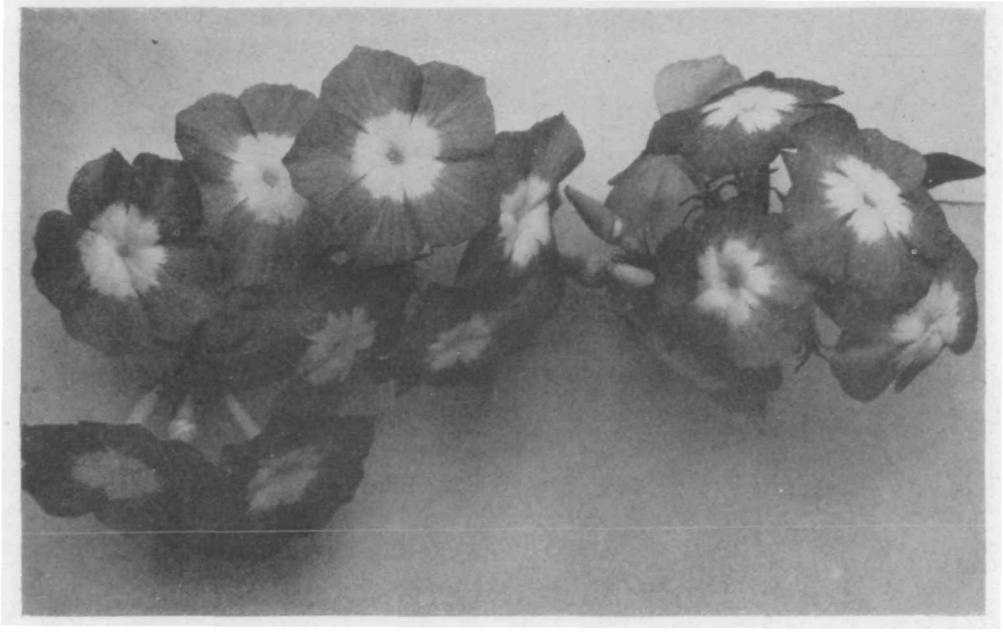


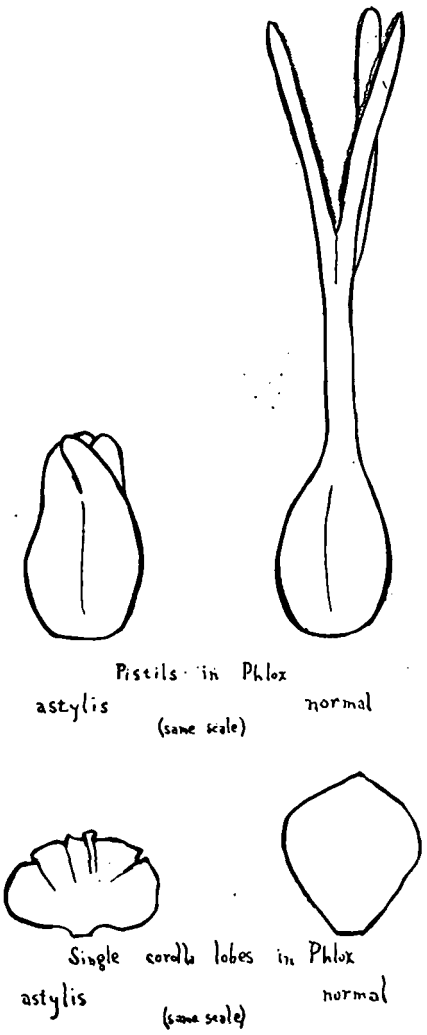
SMALL-EYED PHLOX

FIGURE 1. Pure strains of small-eyed phlox are easily produced by the breeder, but this is not possible with *orbicularis,* for a study of its genetic constitution proves it to be of hybrid origin. Three types of plants, having *orbicularis, astylis,* or small-eyed flowers, are produced by self-fertilized *orbicularis* seed, but the cross between *astylis* and small-eye produces only *obicularis* plants.

IN 1920 there appeared in some cultures of Drummond's phlox grown from German seed a striking and unexpected type of flower. It cropped out in two individuals of a variety supposed to have only normal pink flowers with a small white center, or eye. The new type of flower was exceptionally small, entirely white, and with ruffled or wavy corolla lobes of relatively great width. Closer examination revealed that while pollen was present in normal abundance the style was totally lacking, hence the name *astylis* bestowed on this variation. (See Frontispiece). Repeated hand pollinations were tried on the *astylis* individuals but not a single seed was formed, and experience of subsequent seasons with other *astylis* plants has confirmed the fact of sterility as far as the ovary is concerned. Fortunately, *astylis* pollen is viable and some crossings in which it was used proved successful.

At the time that the *astylis* plants were discovered the writer had under observation two plants of the *orbicularis* type of *Phlox drummondii.* (See

[1] Contribution No. 40 of the Botany Dept., Pennsylvania State College.



NORMAL AND ASTYLIS PISTILS AND COROLLA LOBES

FIGURE 2. *Astylis* plants are sterile because the ovary is undeveloped. Fortunately, the pollen is viable, and crosses with other kinds of phlox can be made. The self-sterility of *astylis* makes it impossible to raise pure *astylis seed*.

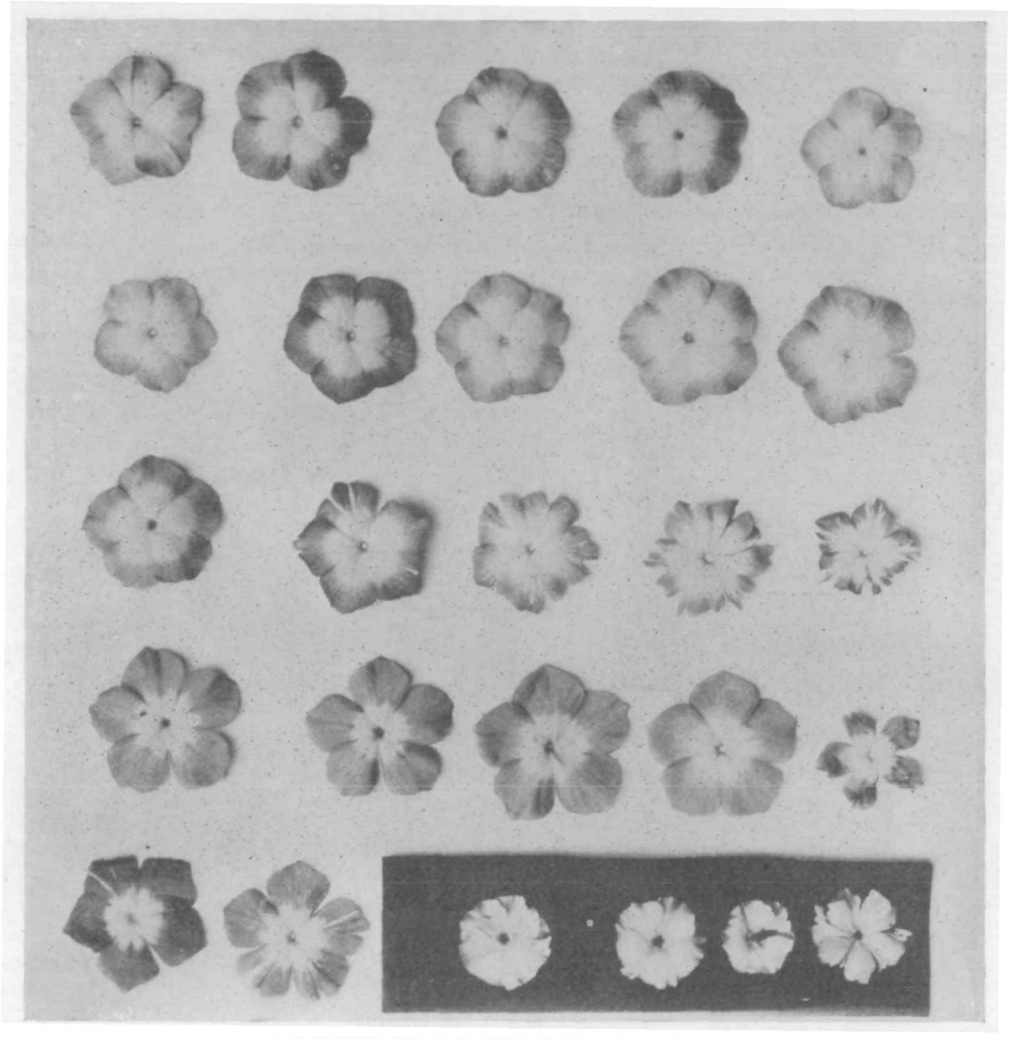
Frontispiece.) The flower in this form is normal, particularly as regards style development, and is distinguished by having the anthocyan pink color more nearly confined to the periphery of the corolla than in any other phlox. The center of the flower is occupied by a relatively large white eye. The genetic analysis of this large eye was undertaken and both self pollinated seed and crosses with other varieties were obtained.

The Origin of the Orbicularis Variety

It was not expected at the time that the paths of investigation of *astylis* and of *orbicularis* would converge and become one, but observation very soon revealed *among the progeny from self-pollinated orbicularis more of the peculiar astylis plants.* These new *astylis* individuals had as sibs large-eyed plants, just like the orbicularis parent, and also small-eyed ones, both kinds bearing normal styles as far as observed. *Orbicularis,* then, on inbreeding, besides having reproduced itself, produced *astylis* plants, and a small-eyed kind as well. Furthermore, it was found that when a plant whose flowers have a small white eye with a wide colored periphery was crossed with *astylis* the progeny all have flowers with large white eyes and narrow periphery; *i. e., the F_1 hybrid generation of small-eye and astylis is orbicularis.* Two such crosses have been made giving rise to a total of nineteen progeny—uniformly *orbicularis.*

Five crossings of *orbicularis* plants and small-eyed ones have been made. There resulted 32 offspring of which twenty had the large white eye and twelve the small white eye.

From the *orbicularis* plants, including both the original commercial ones and those experimentally produced, 14 families have been secured through self-pollination. The total of progeny was 351, of which 84 were *astylis,* and 156 *orbicularis,* while 106 had small-eyed flowers. Five non-*astylis* plants were left unclassified because the eye was intermediate in size. *Astylis* segregates being sterile, could not be further tested by selfing. Three of the small-eyed segregates arising in the experiments gave on selfing 56 progeny of which 55 were small-eyed and one (a stray seed?) had a large eye. Small-eyed phloxes not included in the present



PROGENY OF AN ORBICULARIS PLANT

FIGURE 3. Each of the twenty-six flowers is typical of the plant from which it came. Note practical absence of anthocyan color in the four *astylis* flowers. In this family the small-eyed and the *astylis* plants (if *astylis* were not self-sterile) would be expected to breed true, whereas the progeny of the *orbicularis* plants would split up again in the next generation much as has been the case above.

study have long been in pedigree cultures of the writer and have never been known to throw anything but small-eyed plants.

It seems, therefore, that the *astylis* condition is dependent on a single recessive gene for its manifestation. There is a group of associated characters apparently due to this single factor. When in homozygous condition there follows an inhibition or loss of the style, reduction of the stigmatic branches, increase in the relative diameter of the corolla lobes, ruffling of corolla lobes, and decrease in the size of the flower. The existence of the large-eyed condition is due to this *astylis* gene in heterozygous condition. It converts the small-eyed flower into the large-eyed kind by limiting the develop-

PLANTS OF THE THREE TYPES

FIGURE 4. The effect of the *astylis* gene seems to be to inhibit the development of anthocyan color in the central "eye" of the flower, when in the heterozygous condition, and to result in the development only of this "eye" region of the petals when it is in the "pure" or homozygous state. Note that the size of the *astylis* flower is approximately that of the "eye" region in the *orbicularis* form.

ment of the anthocyan color in the corolla to a narrower peripheral ring. curiously enough, the large white eye is not brought out when the *astylis* gene is homozygous. It seems then to cause the cutting off from development of the corolla periphery, the part that would show the blade color, leaving merely the large white eye; hence, too, the small size of the flower blade. A white *astylis* bloom may be looked upon as just the eye region of a flower with large white eye that has lost its periphery due to the absence of the gene. Figure 3 represents one entire family secured by inbreeding an *orbicularis* parent whose large white eye was surrounded by a Tyrian-pink border. All the non-*astylis* plants have borders of this color, but the *astylis* sibs of these colored plants are white or practically so. Occasionally a faint fleck or tinge of anthocyan may be detected on such plants.

Is it possible to interpret this situation on the basis of a close linkage of factors for white and *astylis?* Certain details of the experiments make this proposition unlikely. Some of the *orbicularis* plants of 1921 were heterozygotes of white and cream.[2] The cream had been introduced through a normal non-*astylis* parent. In 1922 six such heterozygous *orbicularis* plants gave 218 progeny as shown in the accompanying table.

These data indicate no linkage of white and *astylis.*

The large-eyed condition found in the variety *orbicularis,* therefore, is a heterozygous character and presents a genetic situation similar to that already reported by the author for the *fimbriate* phlox.[2] One could not expect to secure a true-breeding strain of *orbicularis* with the existant genetic constitution of *Phlox drummondii,* but this investigation shows that stands which are one hundred per cent *orbicularis* may be obtained by hybridizing *astylis* and the small-eyed variety.

TABLE 1. *Distribution of the Progeny of Six Orbicularis Plants.*

Astylis		*Orbicularis*		*Small-eyed*	
White	Cream	White	Cream	White	Cream
40	10	80	24	49	15

[2] The writer has already shown that cream is a simple recessive of white. See *Genetics, V;* 189-248.